Turnitin Mapping Build-Up Area Density Using Normalized Difference Built-Up Index (Ndbi) And Urban Index (Ui) Wetland In The City Banjarmasin

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Abstract. Density and undeveloped land can be identified using digital transformation through remote sensing data. This study aims to map the distribution of building densities with the Normalized Difference Built-Up Index (NDBI) and Urban Index (UI), analyze the comparison of building densities of the NDBI and UI methods, and analyze the relationship between the transformation of NDBI and UI on building densities in Banjarmasin City. The data used to obtain building density image Landsat 8 Oli Tirs. The method used to separate the built area and non-building area using digital classification. The area was developed from the results of the multispectral classification filtered with NDBI and UI transformation for the classification of the building density level. The results of this study indicate that building density has a positive relationship with the transformation of NDBI and UI because the high building density in the transformation of NDBI and UI has a high value. Non-built area and constructed land shows an NDBI accuracy of 91.4505% and 92.5359% accuracy of UI, there is a difference of 1.0854% greater accuracy UI. Overall accuracy exceeding 80% indicates very high accuracy for building density mapping.

1. Introduction

Increase in population and all their activities cause the need for land to increase. The increasing demand for land encourages the development of facilities and infrastructure including housing, roads, bridges, markets, agriculture, and irrigation. As a result, empty land or vegetation turns into a land [1]–[3]. Changes in land use have positive and negative impacts on the environment in Banjarmasin City. Negative effects include increased building density, reduced green open space, and reduced water catchment areas. The positive impact of land-use change for the development of Banjarmasin City is to accommodate the activities of the population and has provided sufficient facilities and infrastructure for the population [4].

Rapid changes in building density make it impossible to use field surveys to monitor changes. The utilization of information from remote sensing is a solution for monitoring building density because it can be done quickly, multi-temporal, and covers a large area [5], [6]. The remote sensing method has advantages over mapping with field surveys, because satellite image data shows the condition of the earth's surface without visiting the entire location, thereby accelerating the monitoring of land change or mapping of an area [7].

Digital remote sensing image processing for built area density studies requires a special transformation to be able to identify the appearance of objects in urban or urban areas. The image transformation models that most effectively distinguish building materials from natural materials

usually utilize the near-infrared, middle infrared, and far-infrared channels because they are sensitive to differences in building materials and natural materials such as water, vegetation, and exposed land [8].

2. Method

Research conducted in Banjarmasin City, South Kalimantan Province with an area of 98.46 km2. The data used for the research are field data, secondary data in the form of Landsat 8 Oli Tirs imagery recorded on August 14, 2019, and the RBI Map of Banjarmasin City in 2004. Data processing in this research is experimental by building and developing spectral transformations. The spectral transformations used are NDBI and UI.

2.1. Data Processing

At this stage, the image used is radiometric correction first to improve the quality of the image used. The image used is not geometric corrected, because the 1T level data is orthorectified. Sensor correction produces a radiance at sensor image, then atmospheric correction is carried out which produces an image at surface reflectance. Atmospheric correction using ENVI 5.4 software. Correction of radiance and reflectance of Landsat 8 images using equation [9]:

$$L = GAIN * DN * \left(\frac{abscal\,factor}{effective\,bandwith}\right) + OFFSET \quad (1)$$

Description:

L	=	*The top-of-atmosphere radiance*
GAIN	=	calibration radiometric depends on absolute band factor in handbook Landsat 8
DN	=	Pixel value in the image
abscal factor	=	calibration is radiometric found in Landsat 8 image metadata
effective bandwith	=	calibration is Radiometric found in Landsat 8 image metadata
OFFSET	=	calibration Radiometric depends on absolute band factors in handbook Landsat 8

$$\boldsymbol{\rho p} = \frac{\boldsymbol{\pi * L\lambda * d2}}{\boldsymbol{ESUN\lambda * cos\,(\theta S)}} \quad (2)$$

Keterangan:

ρ_p	=	*Planetary reflectance*
Lλ	=	*Spectral radiance at sensor's aperture*
ESUNλ	=	*Band dependent mean solar exoatmospheric irradiance*
Θs	=	*Solar zenith angle*
D	=	*Earth-sun distance, in astronomical units*

2.2. Normalized Difference Built-Up Index (NDBI)

Normalized Difference Built-Up Index Method (NDBI) or the built-up area index is an index that uses the middle infrared (SWIR 1) and near-infrared (NIR) channels, NDBI is an analogous development of the NDVI transformation, NDBI is used to calculate the built-up area. Research that uses the NDBI index to further bring out the density of urban buildings. NDBI is an effective transformation to identify the appearance of an awakened area [8], [10]. Research that uses NDBI to create more urban developed land uses the equation:

$$\text{NDBI} = \frac{\text{SWIR 1} - \text{NIR}}{\text{SWIR 1} + \text{NIR}} \quad (3)$$

Description:
SWIR 1 = Middle infrared channel
NIR = Near-infrared channel

2.3. Urban Index (UI)

Urban index transformation is a transformation that utilizes a channel Middle infrared (SWIR 2) and near-infrared (NIR).UI provides a fast mapping of constructed or vacant land. Lack of UI index cannot separate the built-up area from bare land effectively, the inability is caused by the complex spectral response generated by the combination of spectral response from built-up area, vegetation and bare land, especially in the case of mixed pixels in areas with heterogeneous features [11]. Research that uses UI to create more urban developed land uses the equation:

$$\mathrm{UI} = \frac{\mathrm{SWIR\ 2-NIR}}{\mathrm{SWIR\ 2+NIR}} + 1 \quad (4)$$

Description:
SWIR 2 = Middle infrared channel 2
NIR = Near-infrared channel

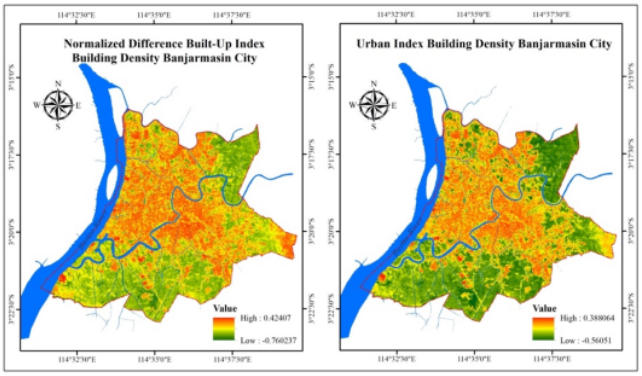
Building density data analysis is carried out through spectral transformation of NDBI and UI which was applied to the Landsat 8 image of August 14, 2019. The statistical analysis carried out included regression and correlation analysis. Regression analysis is a statistical method to see how the form of the relationship between variables, where there is an interplay between the dependent variable and the independent variable. The accuracy test is carried out using an accuracy test matrix which aims to find out how much accuracy is generated from the results of the building density classification based on actual conditions in the field by comparing the results of the NDBI and UI building density classification with the results of measurements in the field.

3. Results and Discussion

The final result of the study is a map of the area density patterns built-in Banjarmasin City. The process consists of data collection starting with image corrections and cropping according to the administrative boundaries of Banjarmasin City, the data extraction stage starting with spectral transformation, field activities, accuracy testing, and analysis.

3.1. Analysis of the Ability of NDBI Spectral Transformation for Density Mapping of Built-in Area

Kepadatan The density of built area is obtained from the results of the Normalized Differences Build-Up Index (NDBI) classification applied to the Landsat 8 Oil image on August 14, 2019. NDBI values indicate that the higher the value of closer to 1, the area density wakes up higher and higher.



b

Figure 1.(a) The results of the transformation of Landsat 8 Oli NDBI August 14, 2019 (b) The results of Landsat 8 UI Transformation Oli August 14th, 2019

The land density built-in Banjarmasin City in 2019 based on the NDBI transformation shows that the range of values resulting from the NDBI spectral transformation ranges from -0.760237 (low built area density) to 0.42407 (high built-up area density), the built-in area density in Banjarmasin City in 2019 is centered in the central area or the Central Banjarmasin District which is marked with an orange hue. The NDBI results of the Landsat 8 Oli image on August 14, 2019, are shown in Figure 1.

3.2. Analysis of UI's Spectral Transformation Ability for Built-in Area Density Mapping

The built-up area density is obtained from the combination of the Urban Index (UI) classification applied to the Landsat 8 Oli image on August 14, 2019. indicates that the higher the value of closer to 1, the higher the built-up area density. The area density built-in Banjarmasin City in 2019 shows that the range of values resulting from the UI spectral transformation ranges from -0.56051 (low built area density) to 0.388064 (high built area density), the built-up area density in Banjarmasin City in 2019 is centered in the central area of Central Banjarmasin District which is marked with an orange hue. The built-up area density is inversely proportional to the vegetation density or a pixel that has a low built-up area density, so the vegetation density will be high. Results Transformation UI Landsat 8 Oli August 14, 2019, is shown in Figure 1.

3.3. Area Density Size Analysis Built NDBI and UI

The processing of built area density data in Banjarmasin City is generated from the NDBI and UI transformation process which is then subtracted from the built-in non-area objects generated through the vegetation index and river polygon data using extract by mask on ArcMap, resulting in City-built area data. Banjarmasin NDBI and UI are further classified into three classes, namely low, medium, and high built area density by dividing the equal interval, namely dividing equally in the resulting range of the built-up area. The area density built-in Banjarmasin City based on NDBI resulted in 3 classifications of built area density.

Table 1. Built-in Area Density Classification NDBI Banjarmasin City

No.	Value	Classification
1.	> / <-0.760237	Low Built Area Density
2.	<0.16808	Medium Built Area Density
3.	<0.42407	High Built Area Density

Table 2. Built Area Density Classification UI Banjarmasin City

No.	Value	Classification
1.	> / <-0.56051	Low Built Area Density
2.	<0.08623	Medium Built Area Density
3.	<0.38806	High Built Area Density

The built-up area density is low covering 1048 ha, medium built area density is 2386 ha, and high built area density is 31 ha. The density of built area in Banjarmasin City based on UI resulted in 3 classifications of built area density. The built-up area density is low of 2419 ha, the density of the constructed area is 64 ha, and the density of the built-up area is 5 ha. The classification of built-in area density based on the NDBI and UI transformations in Banjarmasin City is presented in Table 1 and Table 2.

Table 3. Accuracy of Built Area NDBI

Overall Accuracy = (58724/64214) 91.4505%
Kappa Coefficient = 0.5664

Class	Ground Truth (Pixels) Built-in Area	Non-Built Area	Total
Constructed Area	54359	2044	56403
Non-Built Area	3446	4365	7811
Total	57805	6409	64214

Class	Ground Truth (Percent) Built	Area Non-Built Built	Total
Built Area	94.04	31.89	87.84
Non-Built Area	5.96	68.11	12.16
Total	100.00	100.00	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Built Area	3.62	5.96	2044/56403	3446/57805
Non-Built Area	44.12	31.89	3446/7811	2044/6409

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Built Area	94.04	96.38	54359/57805	54359/56403
Non-Built Area	68.11	55.88	4365/6409	4365/7811

Table 4. Accuracy of Built Area UI

Overall Accuracy = (59421/64214) 92.5359%
Kappa Coefficient = 0.6021

Class	Ground Truth (Pixels) Constructed Area	Non Built Area	Total
Constructed Area	55091	2079	57170
Non-Built Area	2714	4330	7044
Total	57805	6409	64214

Class	Ground Truth (Percent) Built Area	Non-Built Area	Total
Built Area	95.30	32.44	89.03
Non-Built Area	4.70	67.56	10.97
Total	100.00	100.00	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Built Area	3.64	4.70	2079/57170	2714/57805
Non-Built Area	38.53	32.44	2714/7044	2079/6409

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Built Area	95.30	96.38	55091/57805	55091/57170
Non-Built Area	67.56	61.47	4330/6409	4330/7044

3.4. Accuracy Analysis and Validation of Built Area Density NDBI and UI

Accuracy results between the NDBI classification transformation and UI compared to visual interpretation map data with class objects of each non-built and built area shows an NDBI accuracy of 91.4505% and a UI accuracy of 92.5359%, there is a difference of 1.0854% greater UI accuracy of this result by research [12]. Overall accuracy exceeding 80% indicates very high accuracy. Accuracy of Built Area NDBI and UI is presented in Tables 3 and 4.

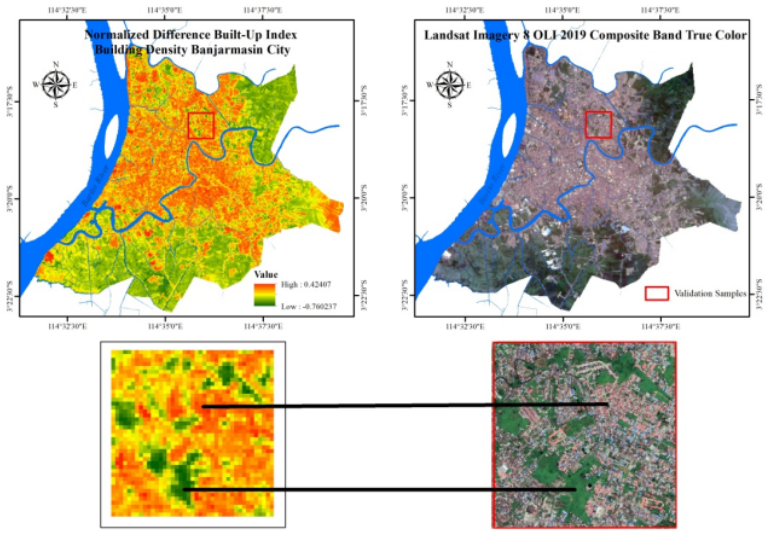


Figure 2.Validation of built area density in Banjarmasin City as a result of NDBI transformation

NDBI and UI validation show a high level of confidence visually where green objects (vegetation / non-building) are transformed NDBI and UI have something in common with the Google Earth image in 2019, namely vegetation objects and orange objects (built area) as a result of the NDBI and UI transformations. It has similarities with the Google Earth image in 2019, namely the built-in area object. The validation of the built area density of Banjarmasin City as a result of the NDBI and UI transformation is presented in Figures 2 and 3. The analysis of the area density validation built by NDBI and UI is presented in Table 5.

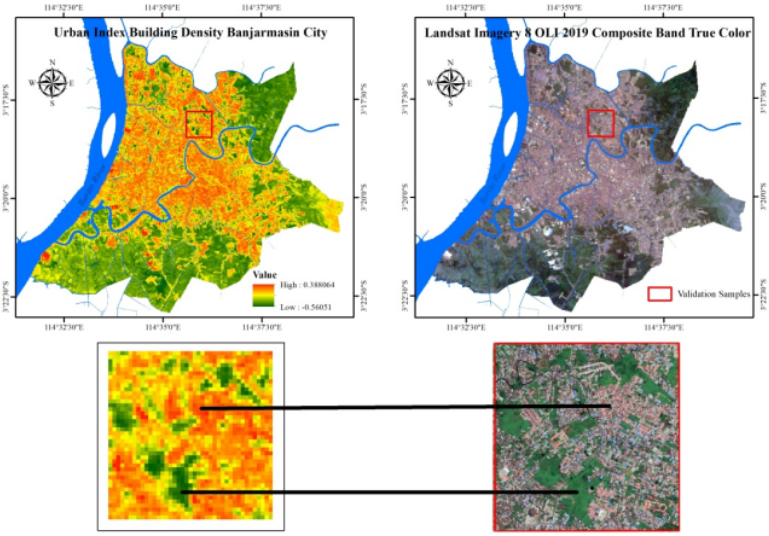


Figure 3. Validation of built area density in Banjarmasin City as a result of UI transformation

Table 5. Density of Built Area Results of NDBI and UI Spectral Transformation

No	Built-up Land Density Class	Area (Hectare)
1	Low	6.1198
2	Medium	4.9037
3	High	1.8104
4	Vegetation	11.8157

The area density built by the NDBI and UI spectral transformations in Table 3 explains that the area density class samples were built Low NDBI and UI transformations with an area of 6.1198 ha plotted at the coordinates of 114.6155ºE and 3.3063ºLS indicate that in the field through Google Earth imagery, built-in area objects such as house buildings are very rare or few. Samples of medium-built area density class transformed by NDBI and UI with an area of 4.9037 Ha were plotted at the coordinates of 114.5853ºE and 3.3168ºLS showing that in the field through google earth images are houses or residential buildings that are denser when compared to low built area density classes. Samples of high density built area density transformed by NDBI and UI with an area of 1,8104 hectares were plotted at the coordinates of 114.5901ºE and 3.3141ºLS showing that in the field through google earth images it is a large office building object. Meanwhile, non-area-built object samples such as vegetation transformed by NDBI and UI with an area of 11.8157 hectares were plotted at coordinates 114.6082ºE and 3.3125ºLS showing that in the field through google earth images are vegetation objects.

4. Conclusion

Area density built-in Banjarmasin City in 2019 based on NDBI transformation It is shown that the resulting value ranges from -0.760237 (low built-up area density) to 0.42407 (high built-up area density), while the UI spectral transformation ranges from -0.56051 (low built-up area density) to 0.388064 (high built-up area density). Area density built-in Banjarmasin City in 2019 is centered in the central area of Central Banjarmasin District.

The area density built-in Banjarmasin City based on NDBI resulted in 3 classifications of built area density. The built-up area density is low covering 1048 ha, medium built area density is 2386 ha, and high built area density is 31 ha. The density of built area in Banjarmasin City based on UI resulted in 3 classifications of built area density. The built-up area density is low of 2419 ha, the density of the constructed area is 64 ha, and the density of the built-up area is 5 ha.

The accuracy between the NDBI and UI classification transformations compared to visual interpretation map data with class objects of each non-built and built area shows an NDBI accuracy of 91.4505% and a UI accuracy of 92.5359%, there is a difference of 1.0854% greater UI accuracy. Overall accuracy exceeding 80% indicates very high accuracy.

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